CR 2005-347

*Cognitive Systems Engineering Center*
*501 Grant Street; Suite 475*
*Pittsburgh, PA 15219*

# ABOVE WATER WARFARE $C^2$ VISUAL DECISION SUPPORT STORYBOARD PROTOTYPE

## Functional Modeling

***Review of AWW C2 Related Reports for Insights to ACWA***

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# A SUMMARY TABLE OF INTENDED USE OF AWW RELATED REPORTS PROVIDED BY DRDC

The following table is an outline of how the CSEC intends to use the reports provided by DRDC for the AWW Visual Decision Support Storyboard Project. Listed is the name, author, and length of each report. Following is the "Intended Use", which summarizes how the content in certain sections of the reports relates to the project. The next three columns estimate the "weight of effort' necessary to utilize the report section, which includes the # of pages of the section, the type of action (ranging from use as a reference, to review of all pages), and the level of transformation required from the given analysis technique to ACWA. A full reference for each report can be seen in Section B of this document.

**Summary of ACWA's Intended Use of AWW Related Reports provided by DRDC**

| | | | | Weight of Effort | | |
|---|---|---|---|---|---|---|
| Report Name | Author | Report Length | ACWA's Intended Use of Report | # of Relevant Pages | Action | Transformation Required |
| Task Analysis of the HALIFAX Class Operations Room Officer (ORO), Sensor Weapons Controller (SWC), and Assistant Sensor Weapons Controller (ASWC) Positions: Mission, Function, and Task (cont.) | CMC Electronics Inc. | 557 Pages - PDF | *Mission Analysis* (summary of domain) to be used as reference to information about domain. | 45 - text | Reference as needed | Average |
| | | | *Function Flow Diagrams - First Level and Second Level Functions* will be used as a reference to fill gaps in FAN | 17 - diagram | Reference as needed | Heavy |

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# Summary of ACWA's Intended Use of AWW Related Reports provided by DRDC

| | | | | Weight of Effort | | |
|---|---|---|---|---|---|---|
| Report Name | Author | Report Length | ACWA's Intended Use of Report | # of Relevant Pages | Action | Transformation Required |
| Analysis Report | | | *Gross and Critical Task Analysis* will be reviewed for "tasks" that require high cognitive work (ie. high *Decisional Components)* and for "tasks" that have a suggested *Risk Mitigation* of "Decision Support Aid." | 300 - table | Review table for "tasks" that require high cognitive work | Average |
| | | | *Mission Composite Scenario* - may give ideas for visualization storyboard prototype | 30 - text | Review for storyboard scenario ideas | Minimal |
| Development of Blueprint/Functional Model for Studying the Combat System Functional Requirements of Canadian Warships | Lockheed Martin Canada Inc. | 1956 Pages - PDF | *Functions and Inter-Function Messages to be used as* last resort as resource to fill gaps in Cognitive Work Requirements and Information Relationship Requirements in the ACWA model | 265 - text, plus others to gain context if relevant | Reference as needed | Very Heavy |
| Functional Analysis of the Canadian Naval Task Group Operational Planning Process | Human*Syste ms* Inc. | 112 Pages - PDF | The Comparison of OPP to the OROs' Mental Models will be used as a reference when gaps in IRRs are found in ACWA modeling and to identify Representation Design Requirements during ACWA design. | 5 - table | Reference as needed | Heavy |

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# Summary of ACWA's Intended Use of AWW Related Reports provided by DRDC

| | | | | Weight of Effort | | |
|---|---|---|---|---|---|---|
| Report Name | Author | Report Length | ACWA's Intended Use of Report | # of Relevant Pages | Action | Transformation Required |
| (cont.) | | | *Expert/Novice Issues* were identified during the Task Analysis. All of these issues will be reviewed for their impact on ACWA modeling | 18 - table | Review table for *Expert/ Novice Issue* insights | Heavy |
| | | | *Actions Requirements* and *Information Requirements* from the Task Analysis will be used as a reference when gaps in Cognitive Work Requirements and Information Relationship Requirements are found in ACWA modeling. | 18 - table | Reference as needed | Heavy |
| Task Analysis of the HALIFAX Class Operations Room Officer (ORO), Sensor Weapons Controller (SWC), and Assistant Sensor Weapons Controller (ASWC) Positions: Information Flow and Processing Analysis Report | CMC Electronics Inc. | 59 Pages - PDF | *Decisions Required* that have been identified by CMC for each task in the analysis will be reviwed for possible insights to ACWA | 15 - table | Review table for CWR insights | Average |
| | | | *Summary of Information Requirements* were identified by CMC for each task. This section will be reviewed for possible insights to Information Relationship Requirements in ACWA. | 15 - table | Review table for IRR insights | Average |

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# Summary of ACWA's Intended Use of AWW Related Reports provided by DRDC

| | | | | Weight of Effort | | |
|---|---|---|---|---|---|---|
| Report Name | Author | Report Length | ACWA's Intended Use of Report | # of Relevant Pages | Action | Transformation Required |
| Recommended Improvements to the HALIFAX Class Frigate | Human*Systems* Inc. | 42 Pages - PDF | All recommendations by HSI will be reviewed for their relevance to the decision support system storyboard prototype and suggested operations room layout to be developed during this project. | 30 - text | Review all pages for relevance to tasks of project. | Minimal |
| Assessing the Impact of Multi-Sensor Data Fusion on Command and Control Operations in the HALIFAX Class Frigate: Recommendations for Measures of Performance and Detailed Test Plan | Human*Systems* Inc. | 67 Pages - PDF | All identified *Measures of Performance* will be reviewed for their insights to Cognitive Work and Information Relationship Requirements inherit in the domain | 4 - table | Review table for insights to CWRs and IRRs and cross check with current ACWA model | Average |
| | | | Testing Plan and Data Evaluation Section will be reviewed by the Decision-Testing Expert for possible insights | 30 - text | Review by DCT expert for insights to DCT | Unknown |
| Review of the TADMUS Decision Support System | Human*Systems* Inc. | 90 Pages - PDF | Included table of ORO "Goals" from previous analysis of ORO position has been included in this report and will be reviewed for relevance to ACWA modeling | 1 - table | Review table for insights to ACWA modeling | Average |

# Summary of ACWA's Intended Use of AWW Related Reports provided by DRDC

| | | | | Weight of Effort | | |
|---|---|---|---|---|---|---|
| Report Name | Author | Report Length | ACWA's Intended Use of Report | # of Relevant Pages | Action | Transformation Required |
| (cont.) | | | Included table of ORO Mental Model of ORO tasks from previous analysis of ORO position has been included in this report - information relevant as resource - also included in *Functional Analysis of Canadian Naval Task Group Operational Planning Process Report* | 7 - table | content also included in another report - may be used as reference in either report | Heavy |
| Studies of the U.S. Navy Air Defense Threat Assessment: Cues, Information Order, and Impact of Conflicting Data | Pacific Science and Engineering Group, Inc. | 75 Pages PDF | ACWA could use the data list within the report to initiate guided KE in an attempt to identify Information Relationship Requirements needed for Decision Making. | 4 | Reference as Needed | Heavy |

# B REFERENCES

CMC Electronics Inc. (2002). *Task Analysis of the HALIFAX Class Operations Room Officer (ORO), Sensor Weapons Controller (SWC), and Assistant Sensor Weapons Controller (ASWC) Positions: Information Flow and Processing Analysis Report.* Prepared for Defense Research and Development Canada.

CMC Electronics Inc. (2002). *Task Analysis of the HALIFAX Class Operations Room Officer (ORO), Sensor Weapons Controller (SWC), and Assistant Sensor Weapons Controller (ASWC) Positions: Mission, Function, and Task Analysis Report.* Prepared for Defense Research and Development Canada.

Human Systems Inc. (2002). *Assessing the Impact of Multi-Sensor Data Fusion on Command and Control Operations in the HALIFAX Class Frigate: Recommendations for Measures of Performance and Detailed Test Plan.* Prepared for Defense and Civil Institute of Environmental Medicine.

Human Systems Inc. (2001). *Recommended Improvements to the HALIFAX Class Frigate.* Prepared for Defense and Civil Institute of Environmental Medicine.

Human Systems Inc. (2001). *Review of TADMUS Decision Support System.* Prepared for Defense and Civil Institute of Environmental Medicine.

Human Systems Inc. (2000). *Functional Analysis of the Canadian Naval Task Group Operational Planning Process.* Prepared for Defense and Civil Institute of Environmental Medicine.

Lockheed Martin Canada Inc. (2000). *Development of a Blueprint/Functional Model for Studying the Combat Systems Functional Requirements of Canadian Warships.* Prepared for DGMEPM.

Pacific Science and Engineering Group Inc. (2002). *Studies of U.S. Navy Air Defense Threat Assessment: Cues, Information Order, and Impact of Conflicting Data.* Prepared for the Simulation and Human Systems Technology Division of SSC San Diego.

# C REVIEW OF CMC ELECTRONICS INC.'S MISSION, FUNCTION, TASK ANALYSIS (MFTA)

## C.1 Overview of the MFTA Framework

CMC Electronics Inc.' Mission Function Task Analysis is aimed at the tasks performed by the SWC/ASWC and ORO positions on the Halifax Class Frigate. The framework for analysis begins with the "high level" missions of the actors. Each mission is then de-aggregated hierarchically to the "tasks." The hierarchy built by CMC happens to be 5 levels, however, is not to be confused with Rassmussen's 5-level hierarchy.

Below is an example of the block-diagram de-aggregation hierarchy produced by CMC. The illustration below is meant to give an idea of the structure of CMC's Mission Function Task Analysis framework. Each block is referred to by CMC as a "Function." The "Functions" actually begin as "missions" (CMC's *Top Level Functions)* and end with "tasks" (CMC's *Fourth Level Functions).* The *Top Level, First Level, and Second Level Functions* are shown below in Figure 1 for only a portion of the analysis.

Figure 2 illustrates the format of the *Gross Task Analysis* portion of CMC's MFTA. CMC does a more robust analysis on the *Fourth Level Functions* or "tasks." The *Decision Requirements* section of the Task Analysis is annotated and will be considered for Tasks with a high *Decisional Component* (also annotated). Other artifacts of CMC's MFTA exist, and can bee seen in Appendix A. A complete list of the CMC analysis artifacts are listed, along with examples, descriptions, and relationships to ACWA for each.

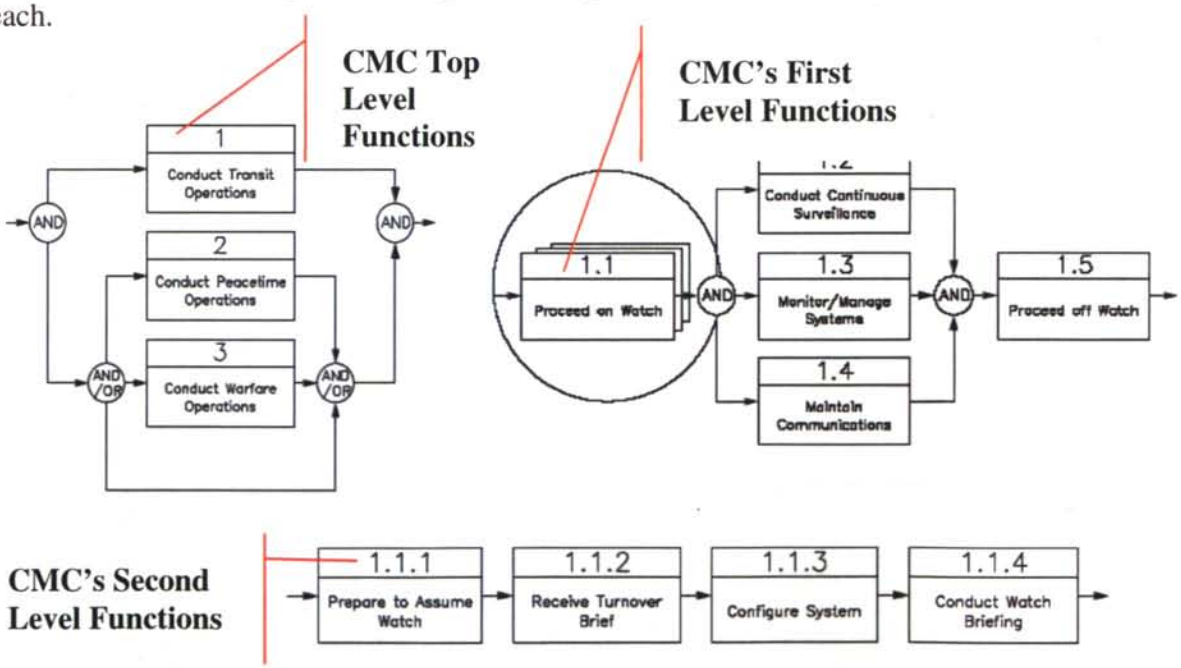


**Figure 1: Example - CMC's Hierarchical Mission to Task De-aggregation Diagram**

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CMC ELECTRONICS INC.
HUMAN FACTORS ENGINEERING

DOC NO
1000-1242

# ANNEX F - SWC/ASWC GROSS TASK ANALYSIS RESULTS

| | | |
|---|---|---|
| **Top Level:** | 1 | Conduct Transit |
| **First Level:** | 1.1 | Proceed On Watch |
| **Second Level:** | 1.1.1 | Prepare To Assume Watch |
| **Third Level:** | 1.1.1.1 | SWC Task |

| | | |
|---|---|---|
| **Task Number:** | 1.1.1.1(d) | Discuss watch conduct with ORO |
| **Source Task:** | 1.1.1.1(d) | |

**Task Completion Times**

| | |
|---|---|
| *Most Likely:* | 120 |
| *Max :* | 300 |
| *Min :* | 20 |

**Description:** Prior to assuming the watch the operator discusses expectations of the upcoming watch with the oncoming ORO. Discussion points include, but are not limited to, team assignments, and preparation for serials, events and taskings anticipated to occur during the upcoming watch. The operator may take written notes for future reference.

**Initiating Conditions:**
1. Coming on watch
2. Conducted periodically as required
3.

**Information Required:**
1. Details of on-going and/or planned activities
2. Mission requirements and objectives
3. ORO's/Command's directions/intentions
4.

**Action Requirements:**
1. Conduct face-to-face conversation
2. Write
3.

**Information Available**
1. Required information is available in the form of hard copy SOPs/references/documents
2. Required information/direction is provided by ORO/Command
3. Operator may be required to solicit additional information from other ships/units
4.

**Feedback Required:**
1. Verbal Acknowledgement
2.

**Communication Required:**
1. Face-to-Face (Verbal)
2.

**Frequency:** Occasionally
**Accuracy Required:** Low
**Interaction with ORO** ☑

**Decision Component**
This task has a decisional component that forms a moderate amount of the cognitive content.

**Decision Requirements**
The operator must assess the requirements for the watch and determine team assignments

**For "tasks" with a high *Decision Component* the *Decision Requirements* will provide many insights for ACWA**

**Task Criticality Rating (TCR):** 7 **Adjusted TCR:** 7

**Criticality Rationale:**
This task has high potential to adversely affect Mission Effectiveness/Completion if improperly performed. The demands of this task do not approach human performance limits. Further analysis of this task is unlikely to result in improvement.

**Figure 2: Example - CMC's Task Analysis**

## C.2 Places of Potential Input from CMC's MFTA to ACWA

The following diagram shows the places of potential input CMC's Mission Function Task Analysis of the SWC/ASWC and ORO positions of the HALIFAX class Frigate may have for ACWA. Solid arrows depict artifacts that are similar in content to those of ACWA. Dotted arrows depict artifacts that have potential to give insights to ACWA modeling. The highlighted artifacts, although the content they possess does not match that of ACWA, they define areas of CMC's analysis that may be of particular interest to ACWA modelers.

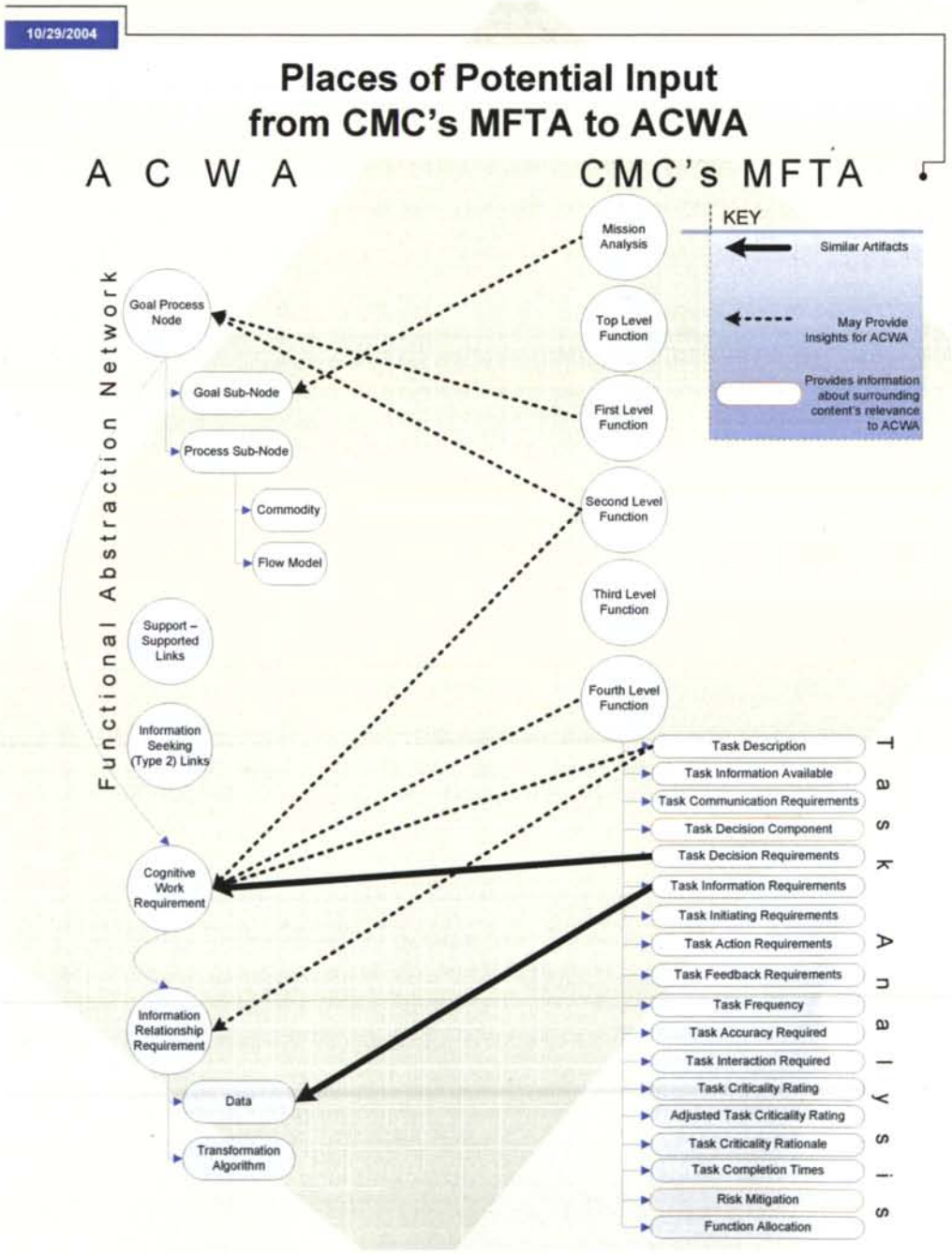


**Figure 3: Places of Potential input from CMC's CTA to ACWA Diagram**

## C.3 Summary of Insights from CMC's MFTA into the AWW C2 Project

From the diagram above, it can be seen that there are many opportunities for CMC's analysis to provide insights to ACWA. CMC's CTA is focused on the mission of an actor (in this case the SWC/ASWC and the ORO) which provides similar information as many KE sources used by ACWA. The following are places where most insights are expected to be found:

- *Mission Analysis* - a summary of the domain - may provide insights to any level of ACWA; however, most insights from this section are expected to be high level goals of the domain. **The *Mission Analysis* section will be used as a reference to information about the domain**, mostly for ship navigation, combat suite, sensor management, and "physical system" knowledge, as those are high level areas to be included in the Functional Abstraction Network. **This section is 45 pages long, and well labeled. Searching for needed information should be fairly straight forward.**

- CMC provides a "task" oriented de-aggregation of an actor's missions. If used as a KE source, the second and third levels of this hierarchy (CMC's *First and Second Level Functions)* may provide insights to ACWA's "Goal Process Nodes" (both Goal sub-nodes and Process sub-nodes) or "Cognitive Work." **The *First* and *Second Level Functions* of CMC's analysis will be used as a reference if gaps in the ACWA modeling are found**. Seventeen pages of *Function Flow Diagrams* are provided by CMC. **The use of these diagrams will require a heavy transformation from CMC's representation as a mission to task de-aggregation to ACWA's goal-means representation.**

- The lowest level of de-aggregation is made of the *Fourth Level Functions,* which are the "tasks" associated with completing the mission. CMC provides a detailed analysis of each task. The relevant information for ACWA includes the following:

    - *Decision Component* rating, which rates the amount of cognitive work associated with the specific "task." When this rating is "high" the decision "task" will provide insights to ACWA's "Cognitive Work Requirements."
    - An explanation of this deeision, labeled as the *Task Decision Requirement* by CMC.
    - A *Risk Mitigation* suggestion is also provided for a limited number of "tasks." Some "tasks" are labeled with a suggestion to provide a "Decision Support Aid."

**Each "task" will be reviewed to identify those with a high *Decision Component Rating* and a *Risk Mitigation* suggestion of "Decision Support System." This will require a high level review of 300 pages, with attention paid only to those meeting the previously stated criteria. Each relevant *Task***

***Decision Requirement*** **will be reviewed and then checked for its location in the FAN.**

- CMC also produced two *Composite Mission Scenarios*. Although they have no direct impact on ACWA, **the *Composite Mission Scenarios* (30 pages) will be read for ideas for the visualization storyboard prototype.**

# D REVIEW OF LOCKHEED MARTIN'S BLUEPRINT/FUNCTIONAL MODEL

## D.1 Overview of the Blueprint/Functional Model Framework

Lockheed Martin conducted a Blueprint/Functional Model for the Combat System Functional Requirements of Canadian Warships. The Blueprint Model is a data-flow model through a 10 level decomposition of operational requirements. Figure 4 depicts the top level of the decomposition hierarchy. Lockheed Martin refers to each box as a *Function* – which is an operational requirement at any level of decomposition. Figure 5 is the data (which LM calls *Inter-Function Messages*) input/output diagram for node 1.2 (shown in figure 4). A more detailed definition of these artifacts can be seen in Appendix B.

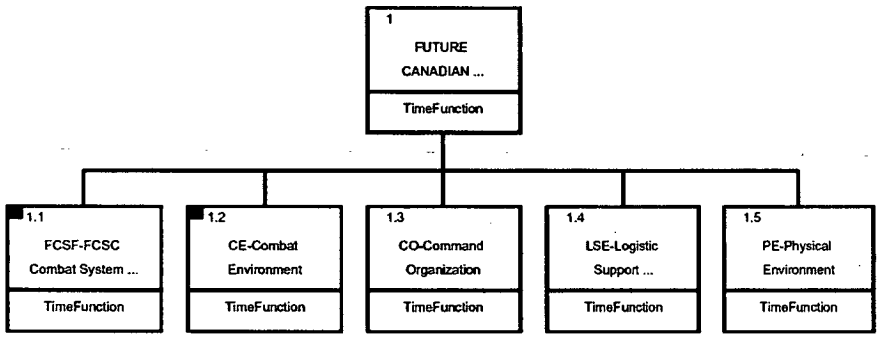


**Figure 4: LM's Blueprint Functional Model Hierarchy, Level 1**

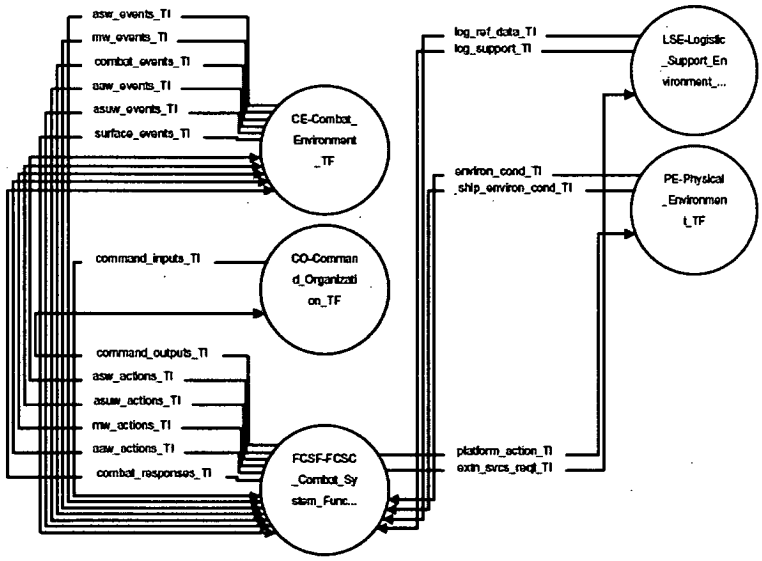


**Figure 5: LM's Blueprint/Functional Model Input/Output Diagram, Level 1**

## D.2 Places of Potential Input from Lockheed Martin's Blueprint/Functional Model to ACWA

The following diagram shows the potential places that LM's Model may provide input to ACWA. None of LM's artifacts are similar to those of ACWA. However, *Functions and Inter-Function Messages* have potential to provide insights to ACWA.

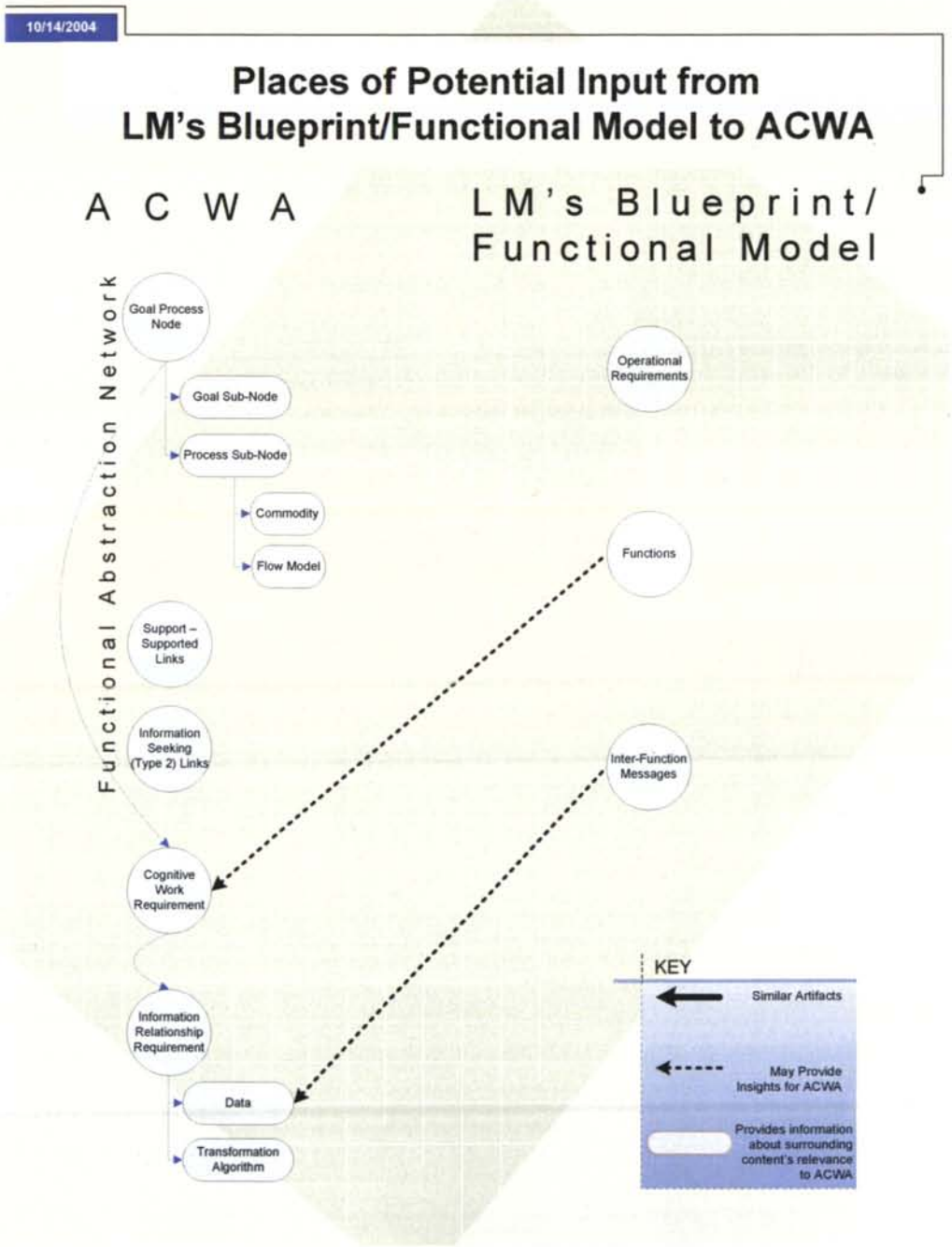


**Figure 6: Lockheed Martin's Blueprint/Functional Model and ACWA Relationship Diagram**

## D.3 Summary of Insights from Blueprint/Functional Model into the AWW C2 Project

The insights provided to ACWA by Lockheed Martin's Blueprint/Functional model will be limited. The Blueprint/Functional model resembles a data flow model, based on system-requirements for Canadian Warships identified by Lockheed Martin. The mapping of artifacts in LM's modeling language to a goal-means decision centered representation will require a considerable amount of transformation. **Lockheed Martin's artifacts will be considered as a last resort to help fill gaps in cognitive work requirements or information requirements that may be identified in the ACWA model:**

- The *Inter-Function Messages* - the data/direction/control and execution/results (inputs and outputs) of the de-aggregated operational requirements, although mostly data-centric, may provide insights to data in context for information requirements in ACWA. **The list of *Inter-Function Messages* is 179 pages long.**
- The *Functions* identified by Lockheed Martin may give insights to Cognitive Work. **The list of *Functions* is 86 pages long.**

**Although a search may be specifically CWRs or IRRs, additional review of other sections in the report may need to be done in order to correctly translate the LM analysis for ACWA modeling. The total length of LM's report is 1956 pages.**

# E REVIEW OF HUMANSYSTEMS INC.'S FUNCTIONAL ANALYSIS

## E.1 Overview of HumanSystems Inc.'s Functional Analysis

Human*Systems* Inc. conducted an analysis of the Canadian Naval Task Group Operational Planning Process. The analysis of Human*Systems* is similar to that of CMC's. The major difference is that CMC focused on the roles or missions of an actor and Human*Systems* focused on the missions of a process, regardless of who (or what – including computer systems) is involved in performing the process. Figure 7 illustrates the block-diagram style de-aggregation hierarchy developed by HSI. Another difference from CMC's analysis is that HSI does not designate the number of levels of de-aggregation. The end (stopping point) is once the mission has reached a "task" level. HSI then performs a Tabular Task Analysis for EVERY "block" in the hierarchy (not just the lowest level). An example row of this task analysis is depicted in Figure 8. A complete list and description of HSI Functional Analysis artifacts can be seen in Appendix C.

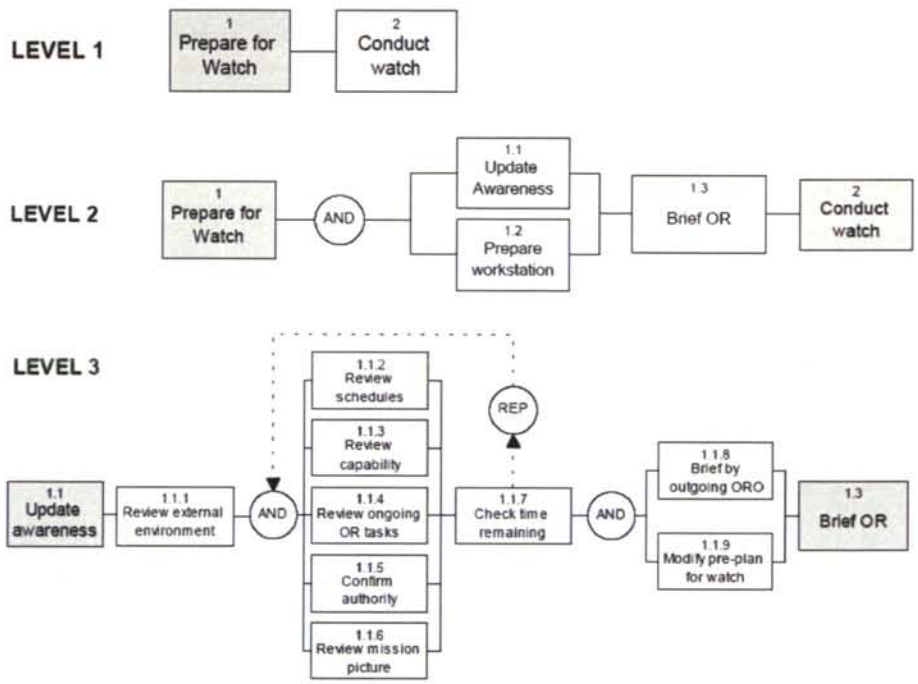


**Figure 7: Example - HSI's De-aggregation Hierarchy Diagram**

| Task No. & Task | Performed by | Initiating Stimulus | Input | Information Requirements | Action Response(s) | Output | Novice/Expert Issues |
|---|---|---|---|---|---|---|---|
| 2.2<br>Produce Mission Statement | Cdr<br>Senior staff | Initiating Directive or Warning Order | Analysis of mission | Initiating directive<br>CF Force Employment Manual Articles 303 & 305 | (Write mission statement)<br>(If warning order received, mission statement is largely provided; specify for TG)<br>(Identify components of mission) | Mission statement (1 sentence summary_ | Including all relevant elements (who, what, where, when, why)<br>Higher command intent is often not clear; the cdr should seek clarification of desired end-state |

**Figure 8: Example - HSI's Tabular Task Analysis**

## E.2 Places of Potential Input from HSI's Functional Analysis to ACWA

The diagram below shows the potential places that HSI's Functional Analysis of the Task Group Operational Planning Process my provide input to ACWA. Dotted arrows depict where insights may be found for ACWA. The closest matching artifact from HSI is the *Information Requirements* – which match ACWA's Data. Most insights are expected to come from the *Novice/Expert Issues* of the Tabular Task Analysis.

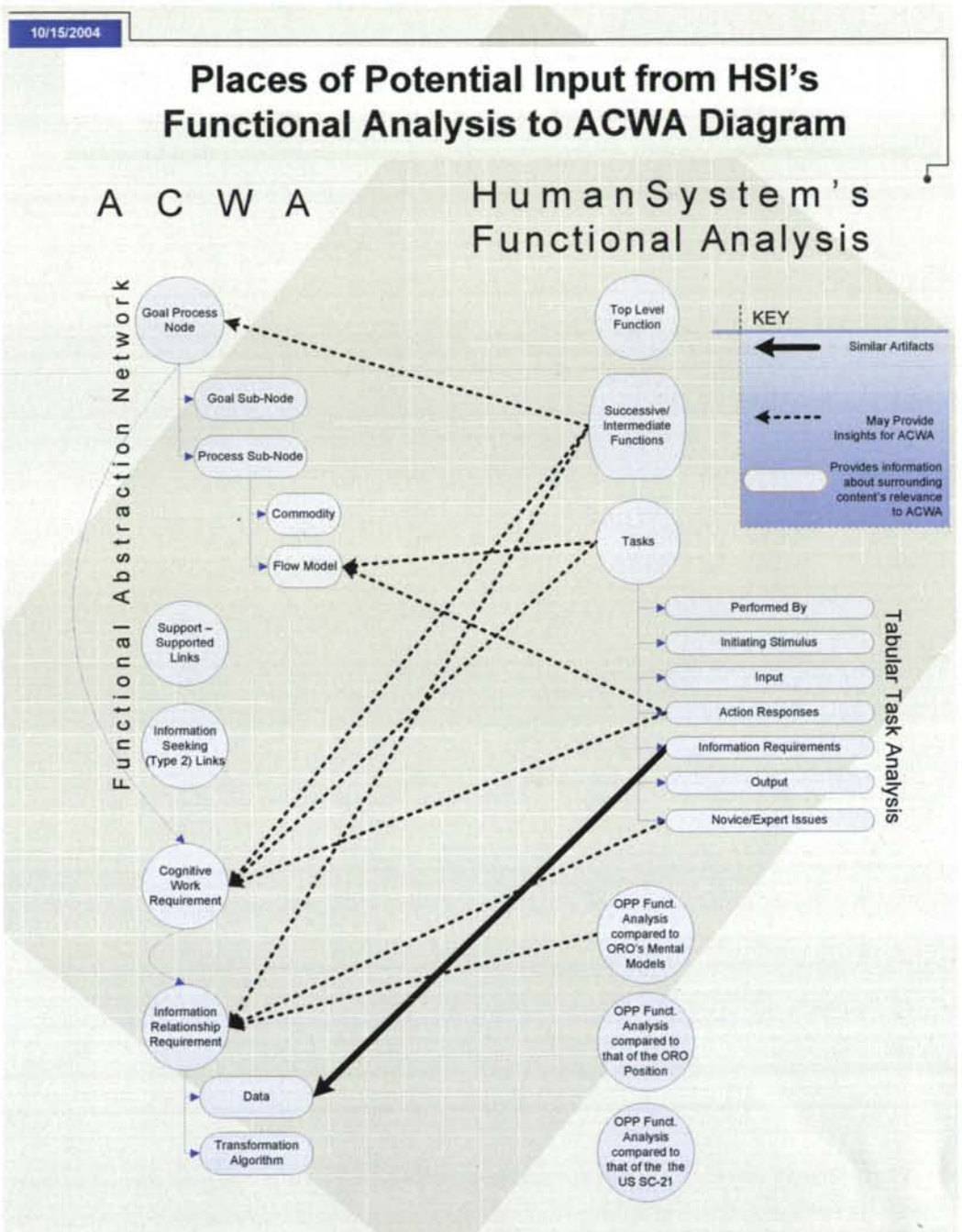


**Figure 9: HSI's Functional Analysis and ACWA Relationship Diagram**

## E.3 Summary of Insights from HSI's Functional Analysis into the AWW C2 Project

The analysis produced by HSI is based on a very similar methodology use in the Mission Function Task Analysis by CMC Electronics Inc. (as described earlier in section C of this report). Naturally, the potential places for input into ACWA are also very similar. **The *Function Flow Model* will be used sparingly (as there is little explanation or context for the *Functions* identified in the diagram) as a resource to fill gaps in the ACWA modeling.** The following are inputs unique to HSI's Analysis:

- HSI discusses the importance of "global" view of the situation – incorporating effects that ownship actions/non-actions have on other ships within the task group. These types of insights will be useful for discovering information requirements in ACWA. HSI discovered these insights during the comparison of the OPP *Functions* to the ORO's Mental Model. **The comparison of OPP to the ORO Mental Model will be used as a reference when gaps in ACWA's "Information Representation Requirements" are found. This section of the report is a 5 page appended table.**
- HSI's Task Analysis states *key* differences in the views of an expert and a novice while performing a task. These statements are expected to be useful for ACWA in discovering cognitive work and information requirements. The statements may provide insights directly for the analysis or they may provide a starting point to ask for further SME input. **All *Expert/Novice Issues* will be considered and when appropriate, addressed in the ACWA modeling. This will require review of the 18 pages of the Task Analysis, however, only a fraction of the *Tasks* have an *Expert/Novice Issue.***
- *Action Requirements* and *Information Requirements* will also be used as a reference when gaps in ACWA's Cognitive Work Requirements and Information Relationship Requirements are found. Again, this requires a review of 18 pages of Task Analysis

# F REVIEW OF CMC'S INFORMATION FLOW AND PROCESSING ANALYSIS REPORT

## F.1 Overview of CMC's Information Flow and Processing Analysis Report

The *Information Flow and Process Analysis Report* by CMC is the third in an increasing effort to analyze the SWC, ASWC, and ORO positions of the HALIFAX class frigate's Operations Room by CMC. This analysis uses the results of the *Mission Function Task Analysis Report* by CMC discussed earlier in section C of this document. In the Information Flow Processing Analysis "Subjective reasoning" was used to identify "Task Sequences" (which correspond to the MFTA's *First Level Functions)* that are most likely to "lead to the identification of decision-making and information flow issues and requirements for the ops room.". Each "Task Sequence" was then analyzed and represented as an *Operational Sequence Diagram* which graphically depicts the information flow within the "Mission Segments" (Task Sequences) against time. The characteristics of the information in these diagrams include:

- Sources of information
- Communication during the task
- Information processing
- Output information

The symbols used to depict this information flow are shown in Figure 10 below.

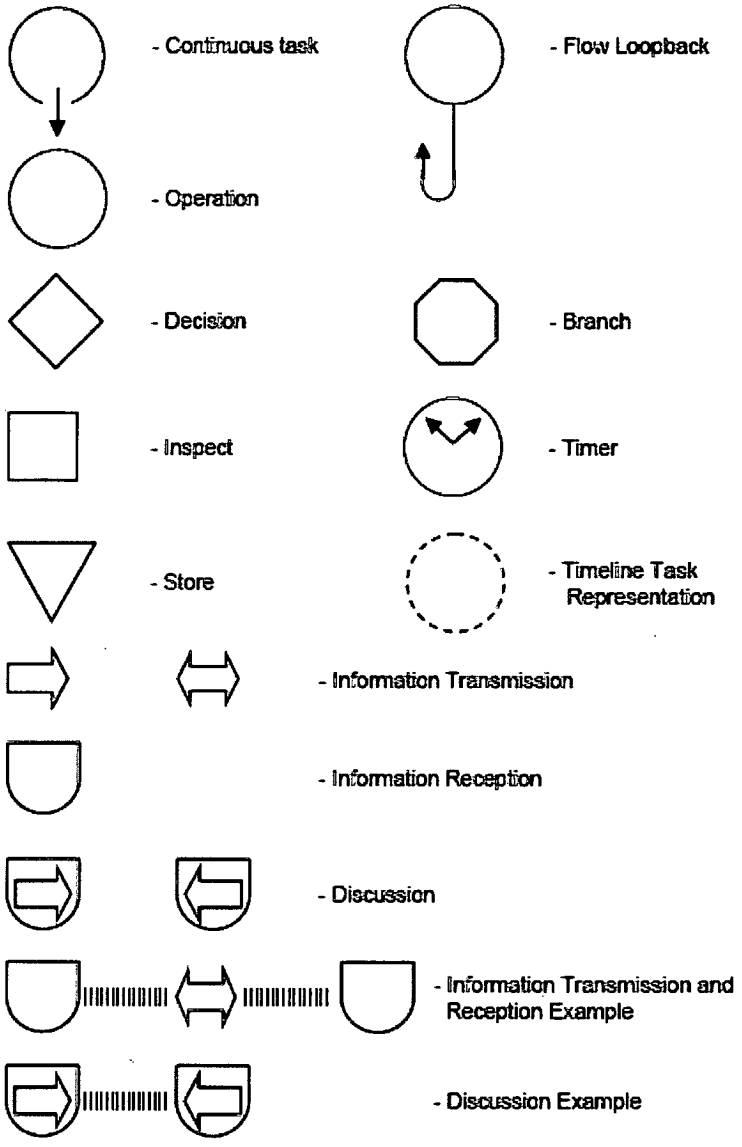


**Figure 10: Operational Sequence Diagram Symbols**

Fifteen "Mission Segments" or "Task Sequences" were analyzed. In addition to the *Operational Sequence Diagrams (OSDs)*, CMC provided a 2-page table for each "Task Sequence" which lists a number of information flow characteristics, including those listed above. An example of this table can be seen in Figures 11 and 12.

CSEC

# ANNEX C - INFORMATION FLOW AND OPERATIONAL SEQUENCE ANALYSIS - Part 1

**Critical Task Sequence:** Monitor and Maintain the RMP/RAP

**Top Level:** 1 Conduct Transit
**First Level:** 1.2 Conduct Continuous Surveillance

**Description:** At sea continuous surveillance is conducted to build and maintain the Recognized Maritime Picture (RMP) and the Recognized Air Picture (RAP). The scenario places the Task Group 57NM north of LAKOS Island on a southerly course. It is a multi-threat environment. The Operations Team must continuously gather, display, interpret and disseminate information. The information may be gained by organic means (radar, EW and Comms intercept) and external such as link or intelligence reports. This critical task sequence is essential for situational awareness during the conduct of all operations.

| Summary of Information Requirements: | Potential Source(s) of Information: | Information Retrieval Method(s): |
|---|---|---|
| 1. Details of on-going and or planned activities including specifics of tactical situation (e.g. threat/friendly forces, ROE, weather and sea state, oceanographic information, etc. | 1. Hard copy sources in form of SOPs/references/documents. | 1. Visual - graphical and alphanumeric. |
| 2. Status of weapons, munitions, systems, and related sensors. | 2. GCCS/CCS/SSD - including any linked information. | 2. Auditory |
| 3. Mission requirements and objectives. | 3. Organic sensors and other operators. | 3. Memory |

| Information Processing Required: | Decisions Required: | Decision Making Processes: |
|---|---|---|
| 1. Cognitive (including memory) | 1. Determine threat type and level based on the interpretation of all available intelligence information. | 1. Cognitive processing (interpret/analyze/assess/determine). |
| 2. Discussion | 2. Determine validity of information displayed on SSD and received by other means. | 2. Operator assist tools - ID criteria check list. |
| 3. Intuitive decisions | 3. Determine the classification of a contact based on several criteria. | **Participants:** CO, ORO, OOW, SWC, ASWC, SAC, ORS, TS, EWS, ARRO, FC |
| 4. Data entry | 4. Determine when situations require the attention of Command or other team members. | |

| Information Produced: | Information Destination(s): | Information Transfer Method(s): | Information Management Processes: |
|---|---|---|---|
| 1. Classification of contact | 1. Internal - Command and team | 1. SHINCOM - internal and external voice circuits | 1. Sequential ordering - specific drill sequence |
| 2. Courses of action | 2. External - Task Group | 2. Electronically - graphical and alphanumeric via CCS and link | 2. Databases or information systems - CCS/GCCS/COWAN |
| 3. Intelligence/threat assessment | 3. | 3. Auditory - to ops room | 3. Stateboards |

**Figure 11: Information Flow and Operational Sequence Analysis Part 1**

CSEC

# ANNEX C - INFORMATION FLOW AND OPERATIONAL SEQUENCE ANALYSIS - Part 2

**Critical Task Sequence:** Monitor and Maintain the RMP/RAP

**Top Level:** 1 Conduct Transit
**First Level:** 1.2 Conduct Continuous Surveillance

**Situational Awareness Issues:**
1. A better understanding of the present tactical picture is generated by the performance of this sequence of tasks.
2. Threat reduction is dependant on the operations room team's ability to acquire and maintain an accurate picture of the tactical situation and to execute the warnings
3. Threat assessment and course of action determination/ recommendation must be associated with this process.
4. The demands of internal communications may create situations where an operator misses vital external queuing.

**Workload Issues:**
1. Operator must concentrate on the tactical picture as portrayed on the SSD to conduct this sequence of tasks.
2. Priority must be determined before the classification process begins for each contact. This is a judgement decision of the highest magnitude.
3. The requirement for accurate information may create the need for operators to repeat verbal reports.
4. The multi-source input environment increases the workload on the operators i.e. the requirement to multitask; read and listen and report during the
5. Fatigue and boredom are factors in maintaining the RAP/RMP.

**Consequences of Error:**
1. Mission - tactical and operational. Improper prioritization will reduce the situational awareness of the team.
2. Safety - own forces or neutral aircraft may be placed in harms way unnecessarily by the results of poor resolve procedures.
3.
4.
5.
6.

**Timing Issues:**
1. Distance, speed and type of contact dependent.
2. The decision making process must be shortened when multiple contacts require analysis.
3. The volume of information that is required by numerous operators increases the time required in the transmission and receipt of information thereby reducing the time available for processing of the information.
4. Current situation - the contact density, the number of contacts within the operating area causes time compression.

## Summary of Findings

1. This critical task sequence is essential for situational awareness during the conduct of all operations.
2. Information is passed both visually and aurally, causing cognitive overload.
3. Every member of the team must maintain situational awareness to ensure the proper priority is given to each contact.
4. Threat assessment and course of action determination/ recommendation must be associated with this process.
5. In a multi-source data fusion environment this sequence becomes more difficult, takes a greater amount of time, and more cognitive ability.
6. Maintaining situational awareness and making tactically correct recommendations becomes increasing more difficult in a multi-source data environment such as a CPF operations room.
7. Priority must be determined before the classification process begins for each contact. This is a judgement decision of the highest magnitude.
8. Fatigue and boredom are factors in maintaining the RAP/RMP.
9. The volume of information that is required by numerous operators increases the time required in the transmission and receipt of information thereby reducing the time available for processing of the information.
10. A Part Task Trainer could be useful in developing an operators abilities with respect to a number of the tasks in this critical sequence.

**Figure 12: Information Flow and Operational Sequence Analysis Part 2**

## F.2 Places of Potential Input from CMC's Information Flow and Processing Analysis Report to ACWA

The diagram below graphically displays the artifacts of CMC's Information Flow and Processing Analysis that may have insights to ACWA. Again, the solid arrows represent artifacts that are consistently similar in content to ACWA artifacts. Dashed arrows depict artifacts that may provide insights to ACWA, however, are not necessarily similar to an ACWA product.

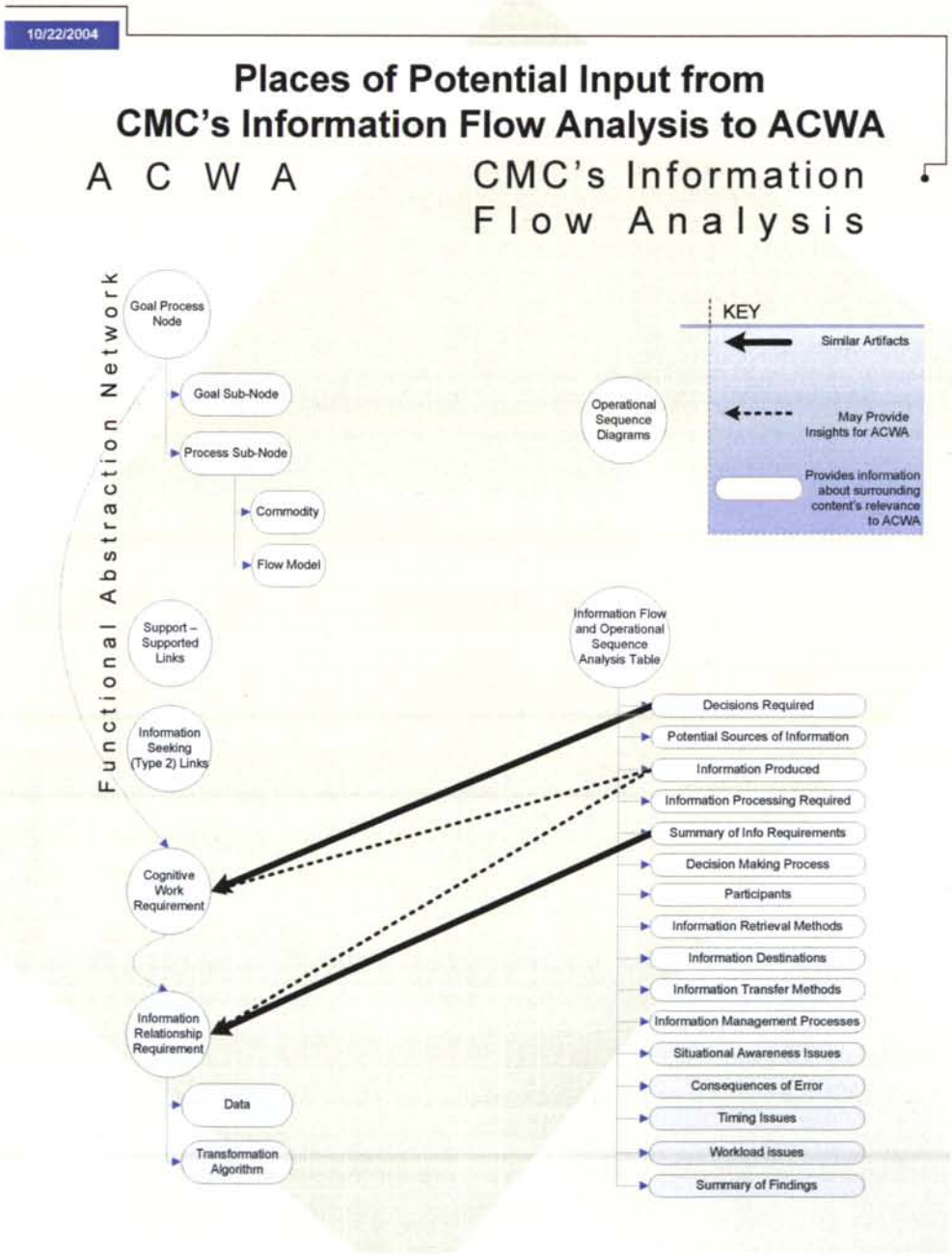


**Figure 13: Places of Potential Input from CMC's Information Flow Analysis to ACWA**

## F.3 Summary of Insights from CMC's Information and Processing Analysis Report to the AWW C2 Project

The Information Flow and Processing analysis by CMC is focused on information transformation and propagation through time as current task sequences are performed. The transformation or exchange of information due to current system and organizational practice is not of use to ACWA. However, the coupling of information flow analysis with task sequences may add extra context for ACWA to extract meaning about the importance of the information, and the transformation with respect to goals of the domain.

- The *Decisions Required* identified by CMC list decisions associated with a given "Task Sequence." Some of these decisions are organizationally specific (Determine content and format of records to be kept) and are not of use to ACWA. Others may provide insights to ACWA's Cognitive Work Requirements. **All *Decisions Required* will be reviewed for their possible relationships to inherit goals of the domain. This will require a review of one section on each of 15 pages included in CMC's Information Flow Analysis Table.**
- The *Summary of Information Requirements* identified by CMC are specific to a task sequence. Value for ACWA may be found if these requirements can be associated with an inherit goal in the domain. **All of CMC's *Information Requirements* will be reviewed for insights to ACWA. This will require a review of one section on each of 15 pages included in CMC's Information Flow Analysis Table.**

# G REVIEW OF HUMANSYSTEMS INC.'S RECOMMENDED IMPROVEMENTS TO THE HALIFAX CLASS FRIGATE

## G.1 Overview of Human*Systems* Inc.'s Recommendation Methodology

Human*Systems* Inc. reviewed a number of reports for their insights to recommendations for improvements on the HALIFAX class Operations Room Officer, Sensor Weapons Controller, and Assistant Sensor Weapons Controller positions. The following reports were highlighted by HSI:

- *Deficiencies in Command and Control Support to the Command Team in the HALIFAX Class* (Webb, R.D.G., & Mclean, D.N., 1997)
- *Literature Survey for Issues in Naval Decision Support* (Bryant, F.J., & Webb, R.D.G., 1999)
- *Cognitive Task Analysis of the HALIFAX Class Operations room Officer* (Matthews, et.al., 1999)
- *CPF Operations Room HCI Deficiencies Documented in the Maritime Operational Deficiencies List* (Kubeck, 1999)

HSI then provided a short (6 page) summary of the findings from the above reports. These finding were then used to identify:

1. Recommended Immediate Improvements for the HALIFAX Class – "improvements that could probably be achieved almost immediately with the proper application of known guidelines and recent research"

   Ex. Reduce Alerts, Follow Common Software Conventions

2. Recommended Additional Modules for the HALIFAX Class CCS – "improvements that would require significant research and development"

   Ex. Add mission planning and preparation tools, Improve conferencing capability

3. Recommended Long Term Measures for the HALIFAX Class CCS – "improvements that could only be achieved with unlimited time and resources"

   Ex. Review ops room layout, Employ user-centered design approaches

## G.2 Places of Potential Input from HSI's Recommended Improvements to the HALIFAX Class Frigate to ACWA

This report will have no input for ACWA's domain modeling. It has been based mostly on a literature review of similar reports, and includes recommendations for improvement to the command and control system of the HALIFAX Class Frigate. This report does not include information about the domain's goals, cognitive work inherit in the domain, or information needed to perform the cognitive work. A figure has not been included in this section as it has been in the previous sections.

## G.3 Summary of Insights from HSI's Recommended Improvements into the AWW C2 Project

Although this report has no direct impact on the ACWA modeling of the AWW C2 domain, it may present issues for system and control room design to be considered in tasks 2 and 5 of this project. **The recommendations by HSI will be reviewed and if found to be in scope for this project, addressed in the design of the decision support system storyboard prototype and operations room layout design. This will require a thorough review of approximately 30 pages of HSI's recommendation report.**

# H REVIEW OF HSI'S ASSESSMENT OF THE IMPACT OF MULTI-SENSOR DATA FUSION ON COMMAND AND CONTROL OPERATIONS IN THE HALIFAX CLASS FRIGATE AND RECOMMENDATIONS FOR MEASURES OF PERFORMANCE AND DETAILED TEST PLAN.

## H.1 Overview of HSI's Recommendations for Measures of Performance and Detailed Test Plan for System Assessment

The report by HSI, *Assessing the Impact of Multi-Sensor Data Fusion on Command and Control Operations in the HALIFAX Class Frigate: Recommendations for Measure of Performance and Detailed Test Plan* was written to provide a "comprehensive Test and Evaluation plan for evaluating the impact of future command decision and technologies (COMDAT) on human and operational performance in the HALIFAX Class operations room". This study resulted in 3 outcomes:

1. **Potential Measure of Performance** – creation was guided by relevant sources and related reports.

   Ex. Accuracy in ignoring irrelevant info, Time to detect change in threat status

2. **A Plan for Piloting Data Collection** – HSI suggests performing a simulation to assess performance and conducting test trials based on 3 categories of ORO tasks (Recognizing Air Picture; Maritime Surface and Sub-surface Pictures; and Recognizing Maritime Picture integrated with Wide Area Picture). HSI also presents considerations while *Preparing the Trial, Running the Trial,* and *Analyzing and Reporting the Trial.*

3. **Suggested Approach to Evaluation** - Step by step procedure to successfully perform trial at NCOT (testing) facility (ex. "Refine measures and scenarios"). Presents *Issues Concerning Data, Research Design Trade-offs and Sample Size Considerations,* and other similar simulation – data driven – test concerns.

## H.2 Place of Potential Input from HSI's Measures of Performance and Test Plan Recommendations to ACWA

Although the purpose of this report is to provide recommended MOPs and test plan, the content may have some insights for ACWA modeling. The *Measures of Performance* identified by HSI actually are a breakdown into the cognitive activity required to achieve the major tasks performed by the Ops Room Team. Although these cognitive activities are arranged by "task," some may provide insights to Cognitive Work Requirements and Information Relationship

Requirements for ACWA modeling. For example, the MOP "Time to detect change in threat status" suggests the importance of noting *change* in threat status, versus only noting *absolute* threat status.

The suggested testing plan and data evaluation sections of the report do not contain information relevant to ACWA domain modeling. Because Measures of Performance are the only input to ACWA modeling from HSI's *Assessing the Impact of MSDF on C2 Operations in the HALIFAX Class Frigate: Recommendations for MOPs and Detailed Test Plan* report, a diagram of this input has not been included.

## H.3 Summary of Insights from HSI's Measures of Performance and Test Plans Recommendations into the AWW C2 Project

The *Measures of Performance* created by HSI contain insights into cognitive work performed by and information requirements needed by the Ops Room Team while performing "major tasks." **Each MOP will be reviewed and possible insights will be noted. This will require review of a 4 page table of MOPs. Those thought to be relevant will require a fair amount of transformation from their placement in a task-based structure to a goal-means representation.**

The suggestions for system testing presented by HSI are very task and situationally based. It is expected that they will provide little insight into the Decision-Centered Testing task of this project. However, the *Assessing the Impact of MSDF on C2 Operations in the HALIFAX Class Frigate: Recommendations for MOPs and Detailed Test Plan* report will be reviewed again closer to the testing phase of this project.

# I REVIEW OF HSI'S REVIEW OF THE TADMUS DECISION SUPPORT SYSTEM

## I.1 Overview of HSI's Review of the TADMUS Decision Support System Methodology

Matthews, Webb, and Bryant (1999) conducted a Cognitive Task Analysis of the Operations Room Officer position of the HALIFAX Class Frigate. HSI used the results of this analysis to review the TADMUS Decision Support System on two dimensions:

1. To determine in the TADMUS DSS provides the needed information for the ORO to accomplish his/her goals.
2. To determine if the displays of the TADMUS DSS are consistent with the ORO mental models of his/her domain.

Both the goals and mental models of the ORO used for the analysis were extracted from the CTA of the ORO position.

## I.2 Place of Potential Input of HSI's Review of the TADMUS Decision Support System to ACWA

As a background for the analysis, HSI included the results from the CTA of the ORO position from Matthews et. al. (1999). This includes a list of the "Goals" of the ORO position. The "Goals" identified by Matthews et. al. are specific to an actor in the domain (the ORO), which is inherently different than the "Goals" of the domain identified by ACWA. Despite this difference, the goals found by Matthews et. al. may provide insights for cognitive work requirements in the ACWA domain model. In addition, notes on the ORO mental representation of his/her tasks (identified in the CTA of the ORO position) have been included. This information was also presented in the HSI *Functional Analysis of the Canadian Naval Task Group Operational Planning Process* report discussed earlier (section E). This information may provide input for Information Representation Requirements of ACWA domain modeling, or Representation Design Requirements during ACWA design.

## I.3 Summary of Insights from HSI's Review of the TADMUS Decision Support System to the AWW C2 Project

The results of the review of the TADMUS DSS will provide little insights for the AWW C2 Project. The review of the TADMUS DSS was based on the results of a CTA of the ORO position. The CTA used for the comparison is inherently different than the cognitive modeling

of ACWA. This calls for ACWA to adopt its own methodology for comparing the ACWA model to the DSS design. Despite this inherit difference in cognitive modeling and the lack of insight from the results of the review of the TADMUS DSS, the information contained in the CTA of the ORO position may provide insights for ACWA modeling. **The goals identified for the ORO position will be reviewed for their relevance to ACWA modeling. This will require the review of a 1 page table, and transformation of any relevant information from a role-based representation to ACWA's goal-means representation.**

# J REVIEW OF PACIFIC SCIENCE AND ENGINEERING GROUP, INC.'S STUDIES OF U.S. NAVY AIR DEFENSE THREAT ASSESSMENT REPORT

## J.1 Overview of U.S. Navy Air Defense Threat Assessment Report

The Overview of U.S. Navy Air Defense Threat Assessment Report by Pacific Science and Engineering Group Inc. is a summary of 3 studies as follows:

1) Study of Cue and Threat Level Relationship (questionnaire)

A baseline "Threat Level" was found (1-5) for varying types of contact classifications, weapons, and radar emitters. Participant were then given a number of "cues" (e.g. speed of contact, altitude, distance from Ownship, etc.) with a varying range of values and asked to describe how the values would change the assessed threat level of the contact. Figure 14 depicts a sample of the questionnaire.

| | "Littoral" AOR (e.g., Persian Gulf) | | | | | "Open" AOR (e.g., Southern Pacific) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Values in this range | lower greatly | lower a little | no change | raise a little | raise greatly | lower greatly | lower a little | no change | raise a little | raise greatly |
| **4. Speed** | | | | | | | | | | |
| Speed steady ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| Speed increase ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| Speed decrease ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| Speed of | | | | | | | | | | |
| under 150 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| 150-250 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| 250-350 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| 350-450 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| 450-550 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |
| over 550 kts ..... 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | |

**Figure 14: Questionnaire from Study One**

The study asked questions in context of 2 types of environments: Littoral and Open Waters. Conclusions were made about difference in Threat Assessment between the two environments.

2) Study of Relative Importance of Threat Assessment Cues (Computer Based Experiment)

Participants were given an ID of an Aircraft (Assumed Friend, Unknown Evaluated, Assumed Enemy). Available were 18 additional hidden data values about the contact (available cues). Participants were asked to assess the ID of the contact (if the given ID was correct) and asked to assess the level of threat the contact posed. The participants could then reveal the desired data to make the assessments. The results of the study identified the "Most often looked at data" and the "soonest looked at data." The study then labeled the top 6 "critical cues" (Origin, IFF Mode, Intelligence, Altitude, Airlane, ES). Figure 15 shows a screen shot of the program used for the experiment.

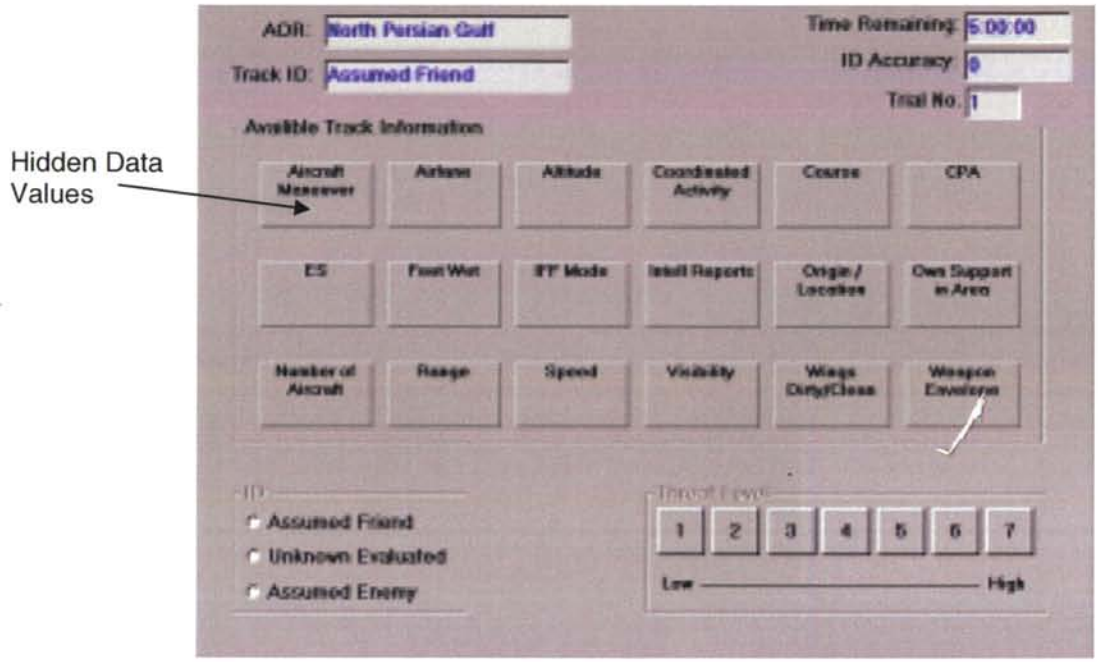


**Figure 15: Screen Shot from Study 2 Computer Program**

3) Study of Effect of Conflicting Information on ID and Threat Decisions (Computer Based Experiment)

The third study provided participants with an already assessed ID of track, and also a track platform. Participants were then provided different levels of conflicting information and again asked to verify contact ID and assess threat level. The study also asked participants to verify track platform, assess intent, and provide a confidence level in the participant's decision. A sample screen shot of the program used for the study if shown in Figure 16.

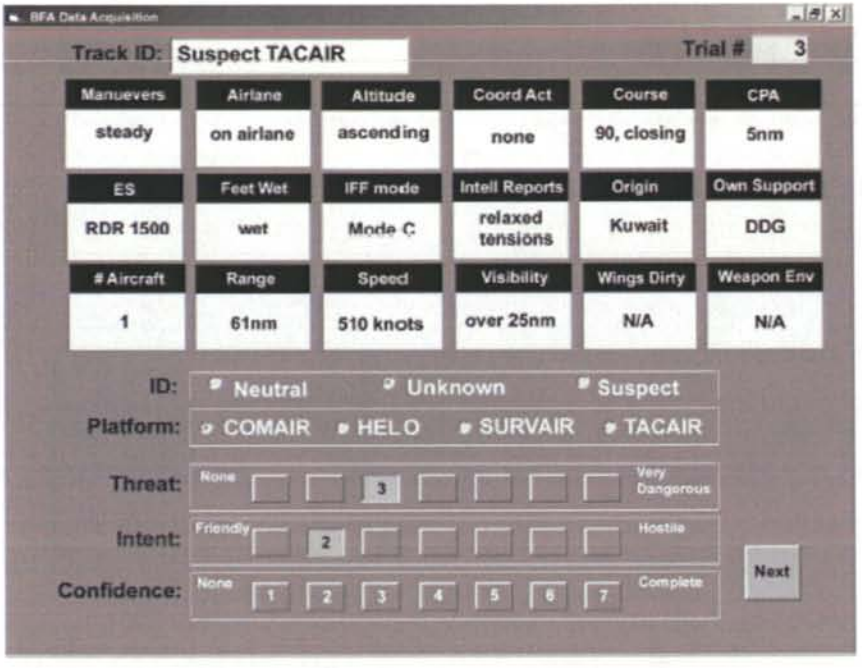


**Figure 16: Screen Shot from Study 3 Computer Program**

All data values were revealed to the participants. Conclusions correlating assessed information about contact with conflicting cues were made (e.g. Participants most likely to change ID of Aircraft with conflicting Origin and IFF Mode).

## J.2 Places of Potential Input from U.S. Navy Air Defense Threat Assessment Report to ACWA

The conclusions from the above studies were extremely data centric. Many of the findings from the report were stated statistically. ACWA does not believe that a mathematical relationship can be found to describe how data effects such complicated decisions as threat assessment. Instead ACWA attempts to understand the transformation an expert does to data in his/her head in order to make decisions. The findings were focused "situationally" in context (which suggests different decision making for different situations). This approach conflicts with ACWA in the sense that ACWA accounts for the fundamentals of decision making, which is consistent across situations, as opposed to the results of decision making, which will likely vary across situations. In addition, the first study used a paper based questionnaire while studies 2 and 3 used a computer based questionnaire. This approach takes decision making out of its natural environment, and assumes participants will be able to recall or identify which decisions he/she will make under pressure while performing his/her job. A questionnaire of this type is essentially a poll of expert opinion, out of context, and does not make any effort to understand the underlying fundamentals of an expert's decision making strategy. ACWA would seek to understand the context in which an expert perceives the data presented.

## J.3 Summary of Insights U.S. Navy Air Defense Threat Assessment Report into the AWW C2 Project

The results of the reviewed report will not provide any insights into the AWW C2 Project. **However, the "data list" in the document could be a starting point for ACWA in a Guided KE session in order to identify Information Relationship Requirements for decision making.**

# APPENDIX A – ARTIFACTS OF MFTA BY CMC ELECTRONICS INC.

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Mission Analysis** | Reports organizational structure, specifications of tools used in domain, and characteristics of operational environment | | The *Mission Analysis* produced by CMC is a robust report of the as-is domain and contains information typically seen in Knowledge Elicitation documents used by ACWA | Can be used as literature-based KE source to possibly identify high-level **goals** of domain. |
| **Top Level Functions** | "Mission Section" – associated with roles actor/position plays in domain | Conduct Peacetime Operations; Conduct Warfare Operations; Conduct Transit Operations | Top Level Functions are meant to be a foundation for further decomposition analogous to ACWA's purpose of the FAN. However, ACWA looks at goals of the domain as the foundation for analysis and CMC's task analysis looks at the missions of an actor in an organization as the foundation of analysis. | The MFTA's Top Level Functions define classes of operational tasks for a given actor. The insights this CTA artifact would give to ACWA will be seen more in their de-aggregation. These top level functions may define a scope around the intrinsic goals of a domain. |

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| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **First Level Functions** | Encompasses the "activities involved in completing the higher level functions" - act as sub-missions to complete higher level mission | Conduct Continuous Surveillance; Maintain Communications | The first level functions are the second layer of the CMC's hierarchy and decomposes the parent *Top Level Function* into a list of sub-missions or *First-Level Functions*. This idea of de-aggregation is analogous to (not the same as) ACWA's supported-supporting relationships between GPNs. CMC's MFTA builds a hierarchy decomposing an actor's mission to his/her individual "tasks." In contrast, ACWA builds a network of intrinsic goals of the domain - finding demanding/supporting relationships between the goals (independent of actors). Though the representations are inherently different, they both act as a framework for the separate methodologies. | This level in CMC's MFTA may provide insights to ACWA's **Goal Process Nodes** |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Second Level Functions** | "Measurable Performance Requirements" to fulfill sub-missions | Detect Contact; Manage Hostile Track; ID Unknown Track | There is not a 1 to 1 match between CMC's MFTA and ACWA artifacts. This makes sense as CMC's model is a 5-level decompositional hierarchy. ACWA does not specify the number of decomposition levels. Because of that, ACWA may find that the decomposition (levels of support) to achieve an abstract domain function (remember, CMC's MFTA "function" is actor-role specific, not domain-goal related) can be more or less than five. Therefore, ACWA may see the content in CMC's decompositional hierarchy as any one of: Goal Process Node (at any level of support in the Functional Network), a piece of a process model, or cognitive work. Although, because CMC's mission-based framework is inherently different than ACWA goal-based framework, a fair amount of transformation will need to occur to represent CMC's findings in ACWA. | The *Second Level Functions* may provide insights in multiple parts of ACWA, namely **Goal Process Nodes (both Goal-sub node or Process-sub node) and Cognitive Work Requirements** |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Third Level Functions** | "Actions" of actors in organization | SWC Task, ASWC Task, ORO Task | Each *Second Level Function* is split into 3 *Third Level Functions:* the SWC tasks, ASWC tasks, and ORO tasks. ACWA does not model actors of a domain. | None |
| **Fourth Level Functions** | "Any human activity consisting of an identifiable amount of subtasks" | Select Radar to be used; Receive secured report from 57mm gun crew; Monitor SSD focus; Adjust console brightness | CMC defines this lowest level of abstraction as the "task" level. CMC combines "actions" and "decisions" as "tasks." ACWA is not concerned with actions of an actor, and not concerned with all decisions for an actor, however, it does model the decisions inherit in a domain (independent of the organizational structure or as-is defined "process"). | Some of CMC's defined "tasks" may give insights into **cognitive work** inherit in the domain, for example, selecting among choices, or monitoring system state. Other of CMC's "tasks" will be more physical or system specific than ACWA models - for example "Adjust console brightness" |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Task Description** | Paragraph explaining "task" | The operator, via the SHINCOM, recommends a change in the degree of readiness to the ORO/Command. This recommendation is based on the operator's detection of a significant event and/or a change in the tactical situation. | Descriptions of goals, process elements, and decisions are noted in ACWA's CSEAR (Cognitive Systems Engineering Analysis Report) - however, ACWA's descriptions are presented more abstractly, where CMC's MFTA presents the task descriptions in as-in terms. | The descriptions of as-is processes and tasks presented by the CTA report may be used by ACWA as a knowledge elicitation source to extract the **decisions** made by and **information** used by actors within the domain. |
| **Task Initiating Requirements** | Cue to start task | Receipt of direction ; start of shift; occurrence of a significant event | ACWA does not attempt to define a "decision initiation cue," rather, ACWA considers the cues for decision making as the state of the system. | It is suspected that the Task Initiating Requirements found by CMC's MFTA are more organizationally/process specific, and will not provide ACWA the insights needed to display the proper cue as data in context. |
| **Task Action Requirements** | Physical actions done by actor to fulfill task | Read; Write; View/inspect appropriate system display | ACWA has no artifacts defining the current actions done by actors | None |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Task Feedback Requirements** | Cue end of task has been achieved | Verbal Acknowledgement; Appropriate information is displayed | ACWA does not produce an artifact describing the organizational cue that a task has been achieved. Rather, the ACWA methodology provides feedback through a continuous display of system state through graphic visualizations of data in context. | It is suspected that the Task Feedback Requirements found by CMC's MFTA are more organizationally/process specific, and will not provide ACWA the insights needed to display the proper cue as data in context. |
| **Task Information Requirements** | Data used to perform task | Status of Weapons Systems/ Munitions; Details of on-going and or planned activities; Mission requirements and objectives | ACWA produces "Information Relationship Requirements" which are defined as the *data in context* necessary for decision making. CMC's MFTA's *Task Information Requirements* are more data-centric. | The **data** listed may provide insights, however, the relationship or meaning needed in the data to support decision making will need to be explored. |
| **Task Information Available** | Current source of data | Required information is available via the CCS/SSD; Required information is provided by other operators | ACWA does not produce an artifact defining the current source of data | The *Task Information Available* will not provide insights for ACWA cognitive modeling. This information may be useful when implementing the designed decision support system |
| **Task Communication Requirements** | Physical method of communication | Voice (SHINCOM); Face to Face (verbal); | ACWA does not model communication between actors | None |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Task Decision Component** | Rating and description of decisional requirements associated with each task (Fourth Level Function). Measure used as an "indication of the level of the operators mental resources required for successful task completion" --- rating 1 (all decision) to 10 (no decision) | This task is a decisional task consisting mostly of cognitive activity only a single aspect is being considered; This task includes visual, auditory, and psychomotor components with only modest decisional aspects to any cognitive content. | ACWA does not attempt to "rate" the level of cognitive demands a decision employs on an actor. ACWA only models those "tasks" (to use CMC's MFTA term) that require cognitive work - and as ACWA says, it models decisions. CMC's MFTA models additional "tasks" that may not necessarily require cognitive work. | It is suspected that CMC's MFTA "tasks" that rate high on the "decisional requirements" scale may give insights of cognitive work requirements for ACWA |
| **Task Decision Requirements** | Explains the cognitive work required in the task | The operator must assess the current situation and decide on the best course of action to recommend to the ORO/Command ; The operator must determine the best sensor for the mission; | This CMC MFTA artifact discusses the cognitive work performed by an actor - similar to a discussion of "Cognitive Work Requirements" created by ACWA | The Task Decision Requirements will provide insights for **Cognitive Work Requirements** |
| **Task Frequency** | A qualitative measurement of how often a task is performed | Rarely; Occasionally; Frequently | ACWA does not model frequency (of decisions). | None |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
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| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Task Accuracy Required** | A qualitative measurement of the importance of precision in a given task | Low; Medium; High | ACWA does not model "accuracy required" | None |
| **Task Interaction Required** | List of actors involved in task | ORO - Command; SWC/ASWC - ORO | ACWA does not model the interaction between actors in a domain | None |
| **Task Criticality Rating** | A qualitative measure of the impact of task not complete, or completed incorrectly | Scale 1 through 10 | ACWA does not produce an artifact analogous to Task Criticality Rating | None |
| **Adjusted Task Criticality Rating** | A qualitative measure of the impact of task not complete, or completed incorrectly - adjusted to account for human limitations and as-is process deficiencies | Scale 1 through 10 | ACWA does not produce an artifact analogous to Adjusted Task Criticality Rating | None |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
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| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Task Criticality Rationale** | Explains the effect criticality has wrt the criteria used to assess Task Criticality | This task has high potential to affect Mission Effectiveness/ Completion, and Efficiency if improperly performed. The demands of this task to not approach human performance limits. Further analysis of this task may result in improvement. | ACWA does not produce an artifact analogous to Task Criticality Rationale | None |
| **Task Completion Times** | "Task performance wrt existing system" | Most Likely, Max and Min time for each task | ACWA does not measure current performance of existing system | None |
| **Risk Mitigation** | Methods identified for improved task performance | Provision of additional training; Change of procedures; Software/Hardware solution; Provide mission planning tools/ decision aids; Improved Alerts | ACWA does not produce an artifact analogous to Risk Mitigation. | CMC's "tasks" with a risk mitigation of "Provide decision aids" - may provide a focus area for ACWA to consider in creating a decision support system |
| **Function Allocation** | An analytical method of prescribing a task to either the human or the machine | Allocation : Human Score: 0.073 Rationale: Weighted Sum | ACWA does not produce an artifact analogous to Function Allocation | None |

| Artifacts of MFTA by CMC Electronics Inc. | | | | |
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| ***Artifact*** | ***Definition*** | ***Example*** | ***Compared to ACWA*** | ***Insights provided to ACWA*** |
| **Composite Mission Scenario (not included in Figure 3 in Section C)** | An event by event walkthrough of a possible situation encountered by the crew on the HALIFAX class ship | Two scenarios were created: a peace time counter drug operation, and a wartime operation involving multiple threats in littoral waters. | ACWA does not formally create "scenarios" | The scenarios created by CMC may give ideas for the storyboard prototype in task 2 of this project. |

**Table 1: Artifacts of CTA by CMC Electronics Inc.**

# APPENDIX B - ARTIFACTS BLUEPRINT/FUNCTIONAL MODEL BY LOCKHEED MARTIN

| *Artifacts of Blueprint/Functional Model by Lockheed Martin* | | | | |
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| | | | | |
| ***Artifact*** | ***Definition*** | ***Example*** | ***Compared to ACWA*** | ***Insights provided to ACWA*** |
| **Requirements** | Qualities or capabilities identified through a literature review of requirements for similar systems | The FCSC CCS shall have the capability and the HCI, under Command Team control, to provide an audio and visual warning to the Command Team MFDs when the Engage Fire Sequence mode is being initiated against an AAW threat; The FCSC CS shall be able to conduct AAW operations in a hostile EW Environment | ACWA produces "Representational Design Requirements" at the end of the domain analysis to define the visual characteristics of the system needed to support the decisions identified in the analysis. LM's Requirements are defined prior to domain analysis - as the "starting point" for the analysis. | ACWA modeling focuses on supporting decision making in a domain. LM's requirements are very situationally based, and provide little insights on the cognitive work or decisions associated with the situation. |

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| Artifacts of Blueprint/Functional Model by Lockheed Martin | | | | |
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| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Functions** | Desired characteristics of the system as means of fulfilling "operational requirements" | Determine Rules of Engagement; Manage Transit Planning | ACWA produces a Functional Abstraction Network of supported-supporting relationships of goals intrinsic in a domain. This representation is then used to identify places of cognitive work/information requirements intrinsic in the domain. LM uses a 10 level hierarchy to depict the de-aggregation of operational requirements. This representation is then used to locate "Inter-Function Messages" as data flow within the domain. | Some of the "Functions" listed by LM sound "decision-like" and may provide insights to **cognitive work requirements** |

| Artifacts of Blueprint/Functional Model by Lockheed Martin | | | | |
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| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Inter-Function Messages** | required data/direction/control and execution/results of the functionality | aaw_ownship_sensor_calc_cov messages, from the Collate AWW Sensor Coverage function, provides the predicted FCSC AWW sensor performance in the current AAW environment to the Coordinate Mission AWW Sensor Coverage Calculation function | Inter-Function Messages define data and data sources used within LM's Blueprint/Functional Model. ACWA produces information requirements needed to perform cognitive work in the domain. | Most of the Inter-Function Messages are very data centric. However, some (like the given example) may provide insights of **data in context** ("Predicted sensor performance with respect to current environment") |

# APPENDIX C – ARTIFACTS OF FUNCTIONAL ANALYSIS BY HUMAN*SYSTEMS* INC.

| ***Artifacts of Functional Analysis of the Canadian Naval Task Group Operational Planning Process by HumanSystems*** | | | | |
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| | | | | |
| ***Artifact*** | ***Definition*** | ***Example*** | ***Compared to ACWA*** | ***Insights provided to ACWA*** |
| **Top Level Functions** | System/Mission Objectives | Prepare for Watch; Conduct Watch | *Top Level Functions* are meant to be foundation for further decomposition analogous to ACWA's purpose of the FAN. However, ACWA looks at goals of the domain as the foundation for analysis and HumanSystems' Function Analysis is situationally or mission specific. | The *Top Level Functions* define classes of operational tasks. The insights this artifact would give to ACWA will be seen more in the de-aggregation. These *top level functions* may define a scope around the intrinsic goals of a domain. |
| **Successive/Intermediate Functions** | The de-aggregate steps from mission objective to specific tasks | Update Awareness; Check time remaining; Conduct Briefing | This idea of de-aggregation is analogous to (not the same as) ACWA's supported-supporting relationships between GPNs. HumanSystem's Functional Analysis builds a mission to task hierarchy. ACWA builds a supported-supporting network among intrinsic goals of the domain as a whole - independent of situation. | These successive mission to task levels are situationally and "task" based, however, may provide insights to **Goal Process Nodes, Process Models, Cognitive Work Requirements; or Information Relationship Requirements** |

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| Artifacts of Functional Analysis of the Canadian Naval Task Group Operational Planning Process by HumanSystems | | | | |
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| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Tasks** | Actions to achieve mission | Collect Data; Collate Data; Format Data; Check Report; Send Report | The Low Level Functions act as tasks that need to be completed by either an actor or a computer. The focus of "system tasks" rather than an "actor's tasks" is similar to ACWA in a sense that the unit being analyzed is the human-environment-technology "system," not a specific actor or computer system. | Although ACWA is not mission specific like HumanSystems' Functional Analysis, the "tasks" identified may provide insights to **Process Models or Cognitive Work** inherit in the domain for ACWA modeling. |
| **Performed By** | Actor(s) allocated to task | Planning Staff; Higher Command; Cdr | ACWA does not identify actors' roles in the domain | None |
| **Initiating Stimulus** | An event (usually operational) dictating the start of the task - usually an output or product from another task | Decision; CONOPS; Recommended COA | ACWA sees initiating stimuli as a state of the system, which ACWA would model as an information relationship requirement. | None |
| **Input** | Organizational Products used for task | List of factors; Cdr's input; CONOPS | ACWA does not model the organizational products of a domain | None |
| **Information Requirements** | Sources of information / resources to complete task; also data used to complete task | time, space, and distance; morale; Costs and risks; CF Force Employment Manual | ACWA models data in context. The data needed to perform a task may be useful, however, further analysis will need to be done to identify the information it provides. | Similar to what ACWA defines as **Data** |

| Artifacts of Functional Analysis of the Canadian Naval Task Group Operational Planning Process by HumanSystems | | | | |
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| ***Artifact*** | ***Definition*** | ***Example*** | ***Compared to ACWA*** | ***Insights provided to ACWA*** |
| **Action Responses** | sub-tasks or procedures to complete task | Develop COAs; Review the situation; Staff Analysis | These as-is procedures and actions may provide information as a KE source for ACWA | May provide insights to **Process Models or Cognitive Work Requirements** |
| **Output** | Organizational Products produced by task | Key dates and time; schedule of activities; Information brief | ACWA does not model the organizational products of a domain | None |
| **Novice/Expert Issues** | Knowledge about completing task that is not necessarily apparent to a non-expert | Should be performed at high level, avoid detail; Understanding of higher command intent; Generating assumptions and recognizing own assumptions; Using internet to acquire a great deal of information | ACWA obtains most information through Subject Matter Experts, to identify cognitive work and information requirements inherit in the domain. These issues may provide direct insights for ACWA, or areas for further analysis. | Expert comments about the completion of tasks have potential to provide insights to **Cognitive Work Requirements** to complete a task or **Information Relationship Requirements.** |
| **OPP Functional Analysis comparison to SC-21 Top-Down Functional Analysis** | HSI compared the *Functions* identified for the Canadian Naval Task Group's OPP with the Top-Down Functional Analysis of the US Navy's SC-21 ship (SC-21 Combat Information Center Top-Down Function Analysis, 1997). | Findings suggest that correspondence between the OPP and SC-21 "functions" are generally at high levels of abstraction. The OPP was found to correspond mostly to the "Plan Mission Function" of the SC-21. | The "SC-21 Tasks" that the author corresponds to the OPP *Functions* are very process specific and will not provide insights to ACWA modeling. Also, the conclusions arrived at by HSI because of this effort do not give information about goal-means relationships or decisions inherit in the domain. | None |

| *Artifacts of Functional Analysis of the Canadian Naval Task Group Operational Planning Process by HumanSystems* | | | | |
|---|---|---|---|---|
| | | | | |
| ***Artifact*** | ***Definition*** | ***Example*** | ***Compared to ACWA*** | ***Insights provided to ACWA*** |
| **Comparison of Functions for the Canadian Naval TG OPP and ORO Position of the HALIFX Class Frigate** | HSI attempted to find similarities in the *functions* identified for the ORO Position (Matthews et al., 1999) and the *functions* identified for the OPP process. | The comparison was done by listing the ORO CTA *Functions*, and noting the "Directly Linked" and "Indirectly Linked" OPP *Functions* | ACWA does not model processes or actor roles in a domain. The analyses of the process or actor's role may provide insights to ACWA, but the comparison of the process to the actor's role does not. | None |
| **Correspondence of Canadian Naval Task Group OPP to OROs' Mental Models** | Compares "Tasks" (HSI's *Functions*) to the mental representation of the ORO | Defines *Level of abstraction* ("Most Concrete" to "Model"); *Level of Focus* ("zoomed-in" versus "zoomed-out" mental display); *Domain of Interest* ("Global" or "Warfare Domain" | ACWA sees these categorizations as describing the need for a micro or macro (or micro-macro) view of the situation, in addition to describing the context in-which data is needed. | For "tasks" relevant to ACWA modeling, the information from this comparison coupled with the information from the *Tabular Task Analysis* may give direction for discovering **Information Relationship Requirements or Representation Design Requirements** |

# APPENDIX D – ARTIFACTS OF INFORMATION FLOW AND PROCESSING ANALYSIS BY CMC ELECTRONICS

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Summary of Information Requirements** | Data or Information that either drives the task (Command's intention) or that is necessary to perform the task (status of weapons) | Classifications and characteristics of contact; Status of weapons, munitions, systems, and related sensors | ACWA identifies information necessary to perform a specific piece of cognitive work. The *Information Requirements* identified by CMC are linked to an entire string of "tasks" (a Task Sequence), where the exact decision requiring the information is not identified. | CMC's *Information Requirements* are similar to ACWA's **Information Relationship Requirements**. For CMC's Information Requirements to provide insights to ACWA, the decision associated with the information will need to be identified (rather than the "Task Sequence" associated with the information - as CMC's analysis has provided) |
| **Potential Sources of Information** | They physical type of source by which the information requirements were acquired | Internal and External Communications; Hard copy sources in forms of SOPs/references/documents/intelligence summaries | ACWA does not identify current sources of information | None |

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Information Retrieval Methods** | The sense used by the actor to obtain the information requirements | Visual; Memory; Auditory | ACWA does not identify the sense an actor currently uses to extract information from the world | None |
| **Information Processing Required** | Type of cognitive work applied to information during task performance | Interpretation of displayed information; Cognitive (including memory); Discussion; Application of Theory | CMC has identified types of information transformations occurring within an actor, however, they have not identified the transformation itself. This artifact does not identify the cognitive work, only lists types that may occur during an entire task sequence. This type is not linked to any particular decision. ACWA identifies types of cognitive work (Goal Monitoring, Process Monitoring, Process Control, etc.) - and links these types to a specific piece of cognitive work. Also - CMC's types are specific to current practice, where ACWA cognitive work types are independent of the current system and current procedures | None |

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| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
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| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Decisions Required** | Cognitive Work associated with Task Sequence | Determine validity and accuracy of information upon which tactical and operational decisions are being made; Determine if the Ship's movements are best controlled from the bridge or the OR | ACWA identifies cognitive work independent of as-is tasks and procedures. Some of CMC's *Decisions Required* are organizationally specific (Determine content and format of records to be kept) - This type of decision is not considered "Inherit to the Domain" by ACWA. | This artifact is similar to ACWA's **Cognitive Work Requirements.** The decisions identified by CMC will need to be linked to inherit goals of the domain in order to provide insights to ACWA. |

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Decision Making Process** | Type of cognitive work applied after information processing in order to reach a conclusion about the information | Options Analysis; Cognitive processing (interpret, analyze, assess, determine); Automated Systems | CMC has identified types of cognitive work performed to reach conclusions after information processing has occurred. They do not link this type to the actual decision, rather, provide a list of types associated with a task sequence. Some of these types are specific to current practice (Options Analysis), others are extremely general (cognitive processing). ACWA identifies types of cognitive work (Goal Monitoring, Process Monitoring, etc.) and uses these types to define a specific piece of cognitive work. | None |
| **Participants** | List of actors involved in Task Sequence | CO, ORO, SWC | ACWA does not model actors involved in current tasks | None |

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Information produced** | Results of information processing and decision making in task sequence | Recommendation of best course of action; Engageability of air threat; Suitability of conducting a counter fire; Optimal equipment state for current tactical situation | To ACWA, the product of decision making (*Information Produced)* in theory should be able to be reverse-engineered to discover the decision (a product of "Optimal equipment state for current tactical situation" should have been found from cognitive work of "Identify optimal equipment state for current tactical situation"). Therefore, ACWA does model the information produced as cognitive work, and would find it redundant to restate the cognitive work as the product of the decision. | The *Information Produced* by a task sequence may give insights to **Cognitive Work Requirements** if the *Information Produced* can be associated with an inherit goal of the domain. Also, it may give insights to **Information Relationship Requirements** if it can be associated with another piece of cognitive work. |
| **Information Destinations** | Actor or group of actors to receive information from task sequence | Internal - command team; External - OTC; External - other surface units | ACWA does not model actors involved in current tasks | None |
| **Information Transfer Methods** | Current tactics for information sharing | SHINCOM - internal circuits; SHINCOM - external circuits; Auditory - discussion | ACWA does not model current actions or tactics taken to share information between actors | None |

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
|---|---|---|---|---|
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Information Management Processes** | Current system used for data storage | Sequential ordering - specific drill sequence; Stateboards; Database or Information System CCS/GCCS/COWAN; Hard copy message filing system | ACWA does not model current system or processes | None |
| **Situational Awareness Issues** | Describes attention issues for actors during currently performed process sequences | In a multithreat environment, maneuvering for one threat may be counterproductive for another threat; With the ORO monitoring the ASWC during this sequence the maintenance of SA becomes more difficult; The maintenance of RMP will be jeopardized due to the heightened importance of the RAP | ACWA does not model current processes. Instead, important states of the environment requiring attention focus will be captured in the representation design requirements of an information relationship requirement. CMC's SA issues are more task-oriented, instead of describing important environment states requiring attention. | None |

| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
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| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Consequences of Error** | Negative effects of improper performance of task sequence | Mission - Improper performance of this task sequence can greatly effect mission success; Safety - improper use of "Weapons VETO Panel" places life and equipment at risk | ACWA does not model current task sequences, therefore, does not model negative effects of improperly performing task sequences | None |
| **Timing Issues** | Criticality of time performing task sequence, suggestions for reducing time to perform task sequence. | The entire sequence must be conducted without delay to ensure the safety of the ship; Improved display aids including a method of alerting the team could reduce the time required in transmission of information; The use of pull down windows based planning tool could increase the efficiency of the operator | ACWA does not have a time component | None |

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| Artifacts of Information Flow and Processing Analysis by CMC Electronics Inc. | | | | |
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| | | | | |
| **Artifact** | **Definition** | **Example** | **Compared to ACWA** | **Insights provided to ACWA** |
| **Workload Issues** | Identifies organization-imposed tasks in addition to operational tasks that compete for a given actors time and effort | Team management and individual responsibilities must be balanced. The operator must brief , attend briefings, and maintain situational awareness; The requirement for accurate information may create need for an increase in time spent in discussion. | ACWA does not model actor's workload | None |
| **Summary of Findings** | Notes about current issues in the OR related to task sequences, some suggestions for improvement | The use of centralized interactive status board which provides visual queuing as to equipment status would reduce verbal communications; The operator must interpret all available information and determine threat type and level while performing all other tasks. | ACWAfocuses on the success of the domain, rather than pointing out the deficiencies in current practices | None |

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